Fishery Data Series No. 92-48

Abundance and Stock Composition of Northern Pike in Minto Flats, 1991

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[1] This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-7, Job No. R-3-4(c)

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ABSTRACT

Estimates of abundance from mark-recapture experiments were 27,418 (SE = 6,800) and 17,633 (SE = 5,480) for northern pike *Esox lucius* over 521 millimeters fork length in 1990 and 1991, respectively in Area I of Minto Flats, Alaska. The majority of the fully recruited northern pike in the spring 1991 sample were in the Relative Stock Density category of "quality" size. Sex was determined for 598 northern pike in the spring of 1991; 481 were females and 117 were males.

KEY WORDS: Northern pike, *Esox lucius*, Minto Flats Alaska, age composition, Relative Stock Density, length-at-age, growth, mark-recapture, abundance.

INTRODUCTION

Next to Arctic grayling *Thymallus arcticus*, northern pike *Esox lucius* are the most sought after indigenous sport fish species in interior Alaska (Holmes 1987). Between 75% and 90% of the annual harvest of northern pike in Alaska comes from interior Alaska with 65% of the estimated harvest taking place in the Tanana River drainage (Mills 1979-1991). Minto Flats has supported the largest sport fishery for northern pike in Alaska in 11 of the previous 15 years (Mills 1979-1991). From 1981-1984, the average sport harvest in Minto Flats was 2,279 northern pike (Figure 1). However, in 1985, a new sport fishery developed on a concentration of overwintering northern pike in the lower part of the Chatanika River (Figure 2). This fishery resulted in an increase in the estimated sport harvest from 2,349 northern pike in 1984 to 4,665 fish in 1985, and 4,903 fish in 1986. Angler reports and limited creel survey sampling (Holmes and Burkholder 1988) indicated that a large portion of the harvest from this new fishery was comprised of prespawning females.

In addition to sport harvests, there is a subsistence fishery on northern pike by the people of Minto Village and Nenana. This subsistence harvest occurs primarily in the spring and fall with gill nets and hook and line. Estimated harvest of northern pike in the subsistence fishery for the years 1983 through 1989 has been reported as high as 3,003 in 1983 (Andrews 1988) and as low as 378 in 1988[1].

Concern that increasing sport harvests combined with subsistence harvests would exceed sustainable yield prompted the Department of Fish and Game (ADF&G) to close the winter sport fishery for northern pike by emergency order in January 1987. In the spring of 1988, two new regulations went into effect. One regulation restricted the sport fishing season to 1 June through 14 October. The other regulation reduced the bag limit from 10 northern pike (two over 760 mm or 30 in) to five northern pike a day, of which one can exceed 760 mm. Along with the new regulations, the ADF&G initiated a stock assessment program in 1987 as part of an effort to assure management is sufficient to maintain this important resource and sport fishery (Holmes and Burkholder 1988, Burkholder 1989 and 1990).

Study Area

Minto Flats is located approximately 50 km west of Fairbanks. It is a 200,000 ha area of marsh and lakes interconnected by numerous sloughs and four major rivers: the Chatanika, Goldstream, Tatalina and Tolovana (Table 1 and Figure 2). Burkholder (1989) found Minto Flats supports two geographic subpopulation of northern pike, one of which resides primarily in Area I. The rivers are slow flowing and meandering, and the lakes are shallow and contain large areas of dense aquatic vegetation. Actual aquatic habitat available for northern pike in Minto Flats consists of an estimated 6,000 ha of water (Holmes and Pearse 1987). Access to Minto Flats is by float equipped

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[1] Neil Shishido; Memorandum; State of Alaska, Department of Fish and Game. 1/13/89. Subsistence Division, 565 University Ave. Fairbanks, AK.

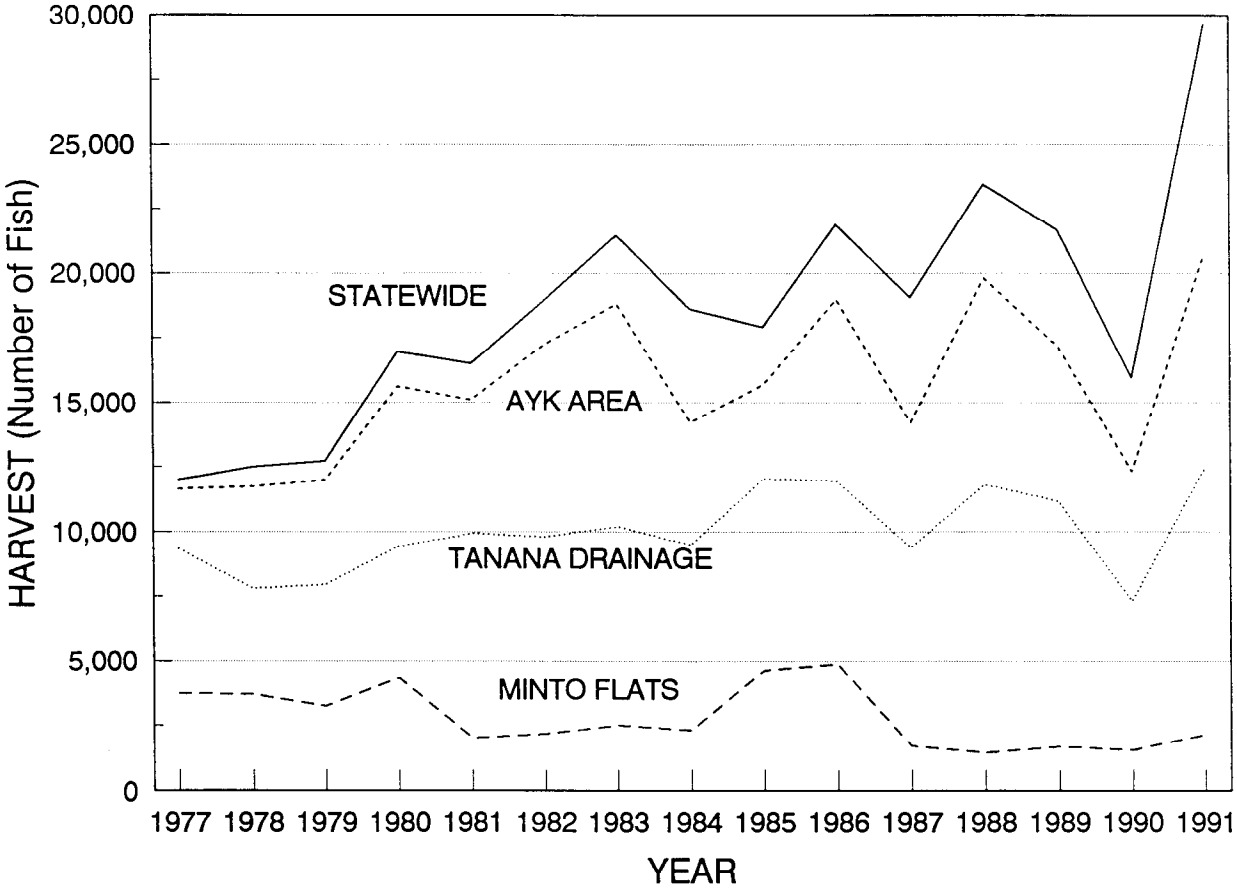

Figure 1. Estimated sport harvest of northern pike in Alaska, the Arctic-Yukon-Kuskokwim Region (AYK), the Tanana drainage, and Minto Flats, 1977 - 1991.

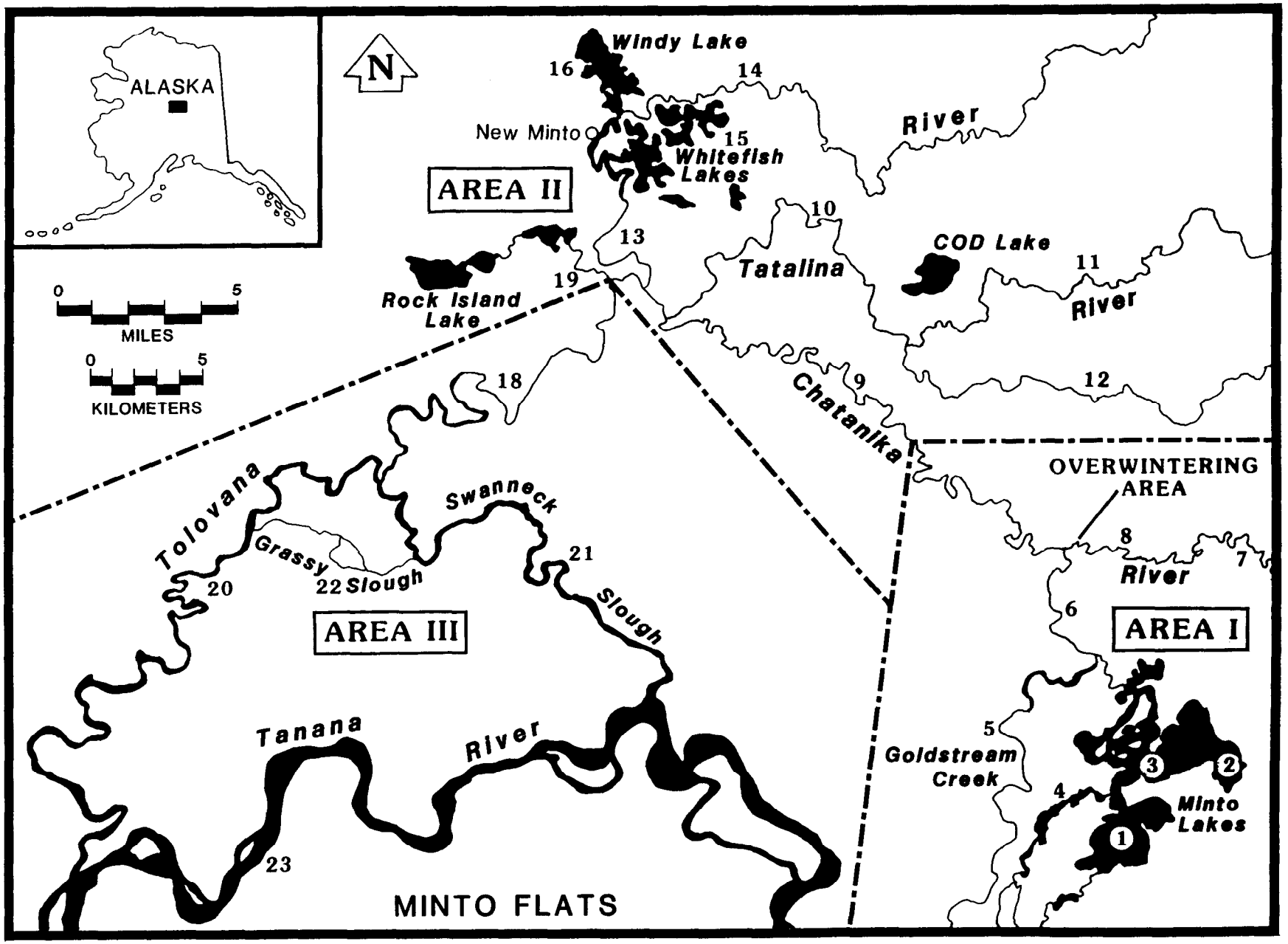

Figure 2. Minto Flats drainage and major sampling areas.

Table 1. Sampling areas and locations in Minto Flats.

Area	Section	Location
I	1	Upper Minto Lake
I	2	Big Minto Lake
I	3	Lake Channels to Goldstream
I	4	Rotten Slough
I	5	Goldstream (above Lake Channels)
I	6	Goldstream (below Lake Channels)
I	7	Chatanika (above Murphy Dome Road)
I	8	Chatanika (Murphy Dome Road to Goldstream)
I	9	Chatanika (Goldstream to Rock Island Slough)
II	10	Tatalina (Chatanika to Forks)
II	11	Tatalina (Above Forks)
II	12	Washington Creek
II	13	Tolovana (Rock Island Slough to Minto Village)
II	14	Tolovana (above Minto Village)
II	15	Whitefish Lakes
II	16	Lakes North of Minto
II	17	Lakes Northwest of Minto
III	18	Tolovana (Rock Island Slough to Swanneck)
III	19	Rock Island Slough
III	20	Tolovana (Swanneck Slough to Tanana)
III	21	Swanneck Slough
III	22	Grassy Slough
III	23	Tanana River

aircraft, by road to Minto Village, by boat via the Tanana River, or by road via the Murphy Dome extension to the Chatanika River.

Study Objectives

Goals of this project are the stock assessment of, and the investigations into the life history of northern pike in Minto Flats to improve the scientific basis of management of the sport fishery.

The specific objectives of the 1991 research program were to estimate:

1. the abundance of northern pike (300 mm FL and longer) in 1991 in Area I (excluding the Chatanika River) of Minto Flats; and,

2. the length and age composition of northern pike in 1991 in Area I of Minto Flats.

In addition, the program in 1991 addressed an objective from 1990, which was to estimate the abundance of northern pike (300 mm FL and longer) in 1990 in Area I (excluding the Chatanika River) of Minto Flats.

METHODS

Study Design

The study design consisted of two mark-recapture experiments based on three sampling events: 4 April to 9 May 1990; 30 April to 14 May, 1991; and 13 August to 22 September, 1991. In 1990 and in the first sampling event of 1991, winged fyke and hoop traps were used as primary sampling gear. Traps were fished in Goldstream Creek and some of the smaller sloughs off the main channel that drains the upper Minto Lakes. Gill nets were used to augment catches during the spring of 1990 and 1991. The spring sampling effort in both 1990 and 1991 intercepted northern pike in Goldstream Creek as they moved from overwintering sites to spawning and summer feeding areas in the Big Minto Lakes complex (Figure 2). In 1990, to determine when this movement would begin, radio transmitters were surgically implanted (Ross 1982) in nine northern pike captured in the overwintering site in the Chatanika River in late March. Aerial tracking was conducted from early April through early May to monitor northern pike movements. Sampling began when a radio tagged northern pike was located in Goldstream Creek. The fall sampling effort in 1991 took place throughout Area I in Minto Flats. Electrofishing and various trap configurations were used.

Data Collection

During all sampling events, captured northern pike were examined, measured, marked, inspected to determine their sex, and sampled to determine their age. Captured northern pike were examined for tags and measured to the nearest 1 mm fork length (FL). Untagged northern pike greater than 299 mm FL judged to be in healthy condition were marked with a Floy FD-68 internal anchor tag inserted posteriorly at the left base of the dorsal fin and released. Because

determination of sex using external characteristics (Casselman 1974) was found to be unreliable, sex was recorded only for northern pike extruding sexual products. A scale sample was removed from each fish greater than 299 mm for estimating age. At least three scales were taken from the preferred zone adjacent to but not on the lateral line above the pelvic fins as described by Williams (1955). Previous analysis (Peckham and Bernard 1987) indicated ages as determined from scales, sagittal otoliths, and cleithra were similar. Scales were stored in coin envelopes and later removed for cleaning and mounting on gum cards. Gum cards were used to make impressions on 20 mil acetate using a Carver press at 137,895 kPa (20,000 psi) heated to 93^{0}C for 30 s. Annuli were counted along their dorsal radius using a Micron 770 Microfiche reader. The same individual determined ages from scales collected in both years. Age was determined once (no replication) for each fish. Scales, cleithra, and vertebrae were taken from all northern pike incidentally killed during sampling.

Data Analysis

Abundance Estimation:

The Chapman modification of the Petersen single-mark method was used to estimate the abundance of northern pike in the spring of 1990 and the spring of 1991 (Seber 1982). The abundance estimates are relevant to the time immediately after the marked fish were released. Conditions for the accurate use of the Petersen estimator are (Ricker 1975):

1. recruitment between sampling events (immigration and growth recruitment) is negligible;

2. mortality (and emigration) between sampling events is negligible;

3. marking does not affect the later catchability of fish (no trap sensitivity or differential natural mortality);

4. fish do not lose their marks between sampling events;

5. all marked fish are reported when recaptured; and,

6. all fish have an equal probability of being marked and released during the first sampling event, or all fish have an equal probability of being captured during the second sampling event, or marked and unmarked fish mix completely between events.

The assumption that there was no growth recruitment can not be made because of the length of the hiatus in both mark-recapture experiments. To remove the growth recruitment, only those fish considered to be fully recruited to the sampling gear were used in the first event and the same restricted population was used during the second event. Northern pike are considered to be fully recruited to the sampling gear used in the spring at 522 mm FL (Pearse 1990). Therefore, only those tagged northern pike ≥522 mm released during the first event and only those fish ≥542 mm (average annual growth of 522 mm northern

pike in Minto Flats is 20 mm) captured during the second sampling event were used in either experiment.

The assumption that there was no size-selective sampling during either event can not be tested directly because the effects of size-selective sampling would be confounded with the effects of growth. To remove the possible effect of size-selective sampling, abundance and composition estimates in both experiments were stratified into two length categories: 522-599 mm and 600 mm and larger.

Abundance ($\hat{N}$) and the $\hat{V}[N]$ for the Petersen estimate were calculated according to the following equations of each length category:

$$\hat{N}_i = \frac{(C_i+1)(M_i+1)}{(R_i+1)} - 1; \text{ and,} \quad (1)$$

$$\hat{V}[N_i] = \frac{\hat{N}_i(C_i-R_i)(M_i-R_i)}{(R_i+1)(R_i+2)}; \quad (2)$$

$$\hat{N} = \Sigma \hat{N}_i \quad (3)$$

$$\hat{V}[N] = \Sigma \hat{V}[N_i] \quad (4)$$

where:

C_i = number of fish from length category i captured during the second event;

M_i = number of fish from length category i marked during the first event; and,

R_i = number of fish from length category i recaptured during the second event.

Composition Estimation:

After a review of Gabelhouse (1984) categories for estimation of Relative Stock Density (RSD) were defined as follows: "stock" size = 300-524 mm (FL); "quality" size = 525-654 mm (FL); "preferred" size = 655-859 mm (FL); "memorable" size = 860-1,079 mm (FL); and "trophy" size = 1,079 mm and longer.

The proportions of the population corresponding to each age and length category were estimated with the following formulas from Cochran (1977) based on a stratified sample:

$$\hat{p}_{ij} = n_{ij}/n_i \tag{5}$$

where:

n_i = the number of fish sampled from length category i in the mark-recapture experiment;

n_{ij} = the number of fish sampled from length category i that belong to group j; and,

$\hat{p}_{ij}$ = the estimated fraction of the fish in length or age group j that belong to length category i.

The variance for $\hat{p}_{ij}$ is:

$$\hat{V}[p_{ij}] = \frac{\hat{p}_{ij}(1 - \hat{p}_{ij})}{n_i - 1} \tag{6}$$

The estimated abundance of length or age group j in the population ($\hat{N}_j$) was calculated as:

$$\hat{N}_j = \sum_i \hat{p}_{ij}\,\hat{N}_i \tag{7}$$

where: $\hat{N}_i$ = the estimated abundance of length category i. The variance for $\hat{N}_j$ was calculated as a sum of the exact variance of a product from Goodman (1960):

$$\hat{V}[N_j] = \sum_i (\hat{V}[p_{ij}]\hat{N}_i^2 + \hat{V}[N_i]\hat{p}_{ij}^2 - \hat{V}[p_{ij}]\hat{V}[N_i]) \tag{8}$$

The estimated fraction of the population that belongs to group j (p_j) is:

$$\hat{p}_j = \hat{N}_j/\hat{N} \tag{9}$$

where: $\hat{N} = \sum \hat{N}_i$. The variance of the estimated fraction was approximated with the delta method (see Seber 1982):

$$\hat{V}[p_j] \approx \sum_i \hat{V}[p_{ij}] \left[\frac{\hat{N}_i}{\hat{N}} \right]^2 + \frac{\sum_i \{\hat{V}[N_i] (p_{ij} - p_j)^2\}}{\hat{N}^2} \qquad (10)$$

Length-at-Age:

Mean length-at-age was calculated as the arithmetic mean length for each age cohort for males, females, and all northern pike for which ages were determined.

RESULTS

Abundance Estimate

The estimated abundance of northern pike over 521 mm FL in Area I (excluding the Chatanika River) was 27,418 in the spring of 1990 (SE = 6,800). The stratified Petersen abundance estimate was composed of 18,170 fish in the 522-599 mm class and 9,248 fish in the 600 mm and larger class. During the first sampling event in the spring of 1990, 2,818 unique northern pike were released with marks, 1,196 of which were ≥522 mm (Table 2). During the second event in the spring of 1991, 811 northern pike were examined (349 ≥522 mm), 22 (12 ≥522 mm) of which were marked during the first event in the of 1990. The length distribution of fully recruited northern pike marked during the first event was significantly different from the length distribution of the fully recruited fish examined during the second sampling event ($D = 0.38$, $P = 0.06$, Figure 3). The length distributions of fish marked during the first sampling event and those recaptured during the second event were also significantly different ($D = 0.23$, $P < 0.001$, Figure 3). Even though these hypothesis tests indicate that growth and/or size-selective sampling in the experiment would have biased estimates from an unstratified analysis, that bias is negligible. The difference between the stratified and unstratified estimates (a measure of the bias in the latter estimate) was small (27,418 and 29,463 respectively). Since the variance was greater for the unstratified estimate (SE = 7,671), the unstratified estimate was discarded.

The estimated abundance of northern pike over 521 mm FL in Area I (excluding the Chatanika River) was 17,633 in the spring of 1991 (SE = 5,480). The stratified Petersen abundance estimate was composed of 14,640 fish in the 522-599 mm class and 2,993 fish in the 600 mm and larger class. During the first sampling event in the spring of 1991, 811 unique northern pike (349 of which were fully recruited) were released with marks (Table 2). During the second event (fall of 1991), 1,389 northern pike (766 of which were ≥522 mm) were examined, 27 (20 ≥522 mm) of which were marked and released during the spring

Table 2. Summary of the number of northern pike from the 1990 and 1991 mark-recapture experiments in Area I of Minto Flats.

Date of Experiments and Sampling Events		Length Categories (mm FL)			
		300 - 521	522 - 599	≥ 600	Event 1
		300 - 541	542 - 619	≥ 620	Event 2
1990					
4/24 - 5/9/90	Marked	1,622	789	407	
4/30 - 5/14/91	Examined	492	252	67	
	Recaptured	10	10	2	
1991					
4/30 - 5/14/91	Marked	462	179	170	
8/13 - 9/22/91	Examined	623	487	279	
	Recaptured	7	5	15	

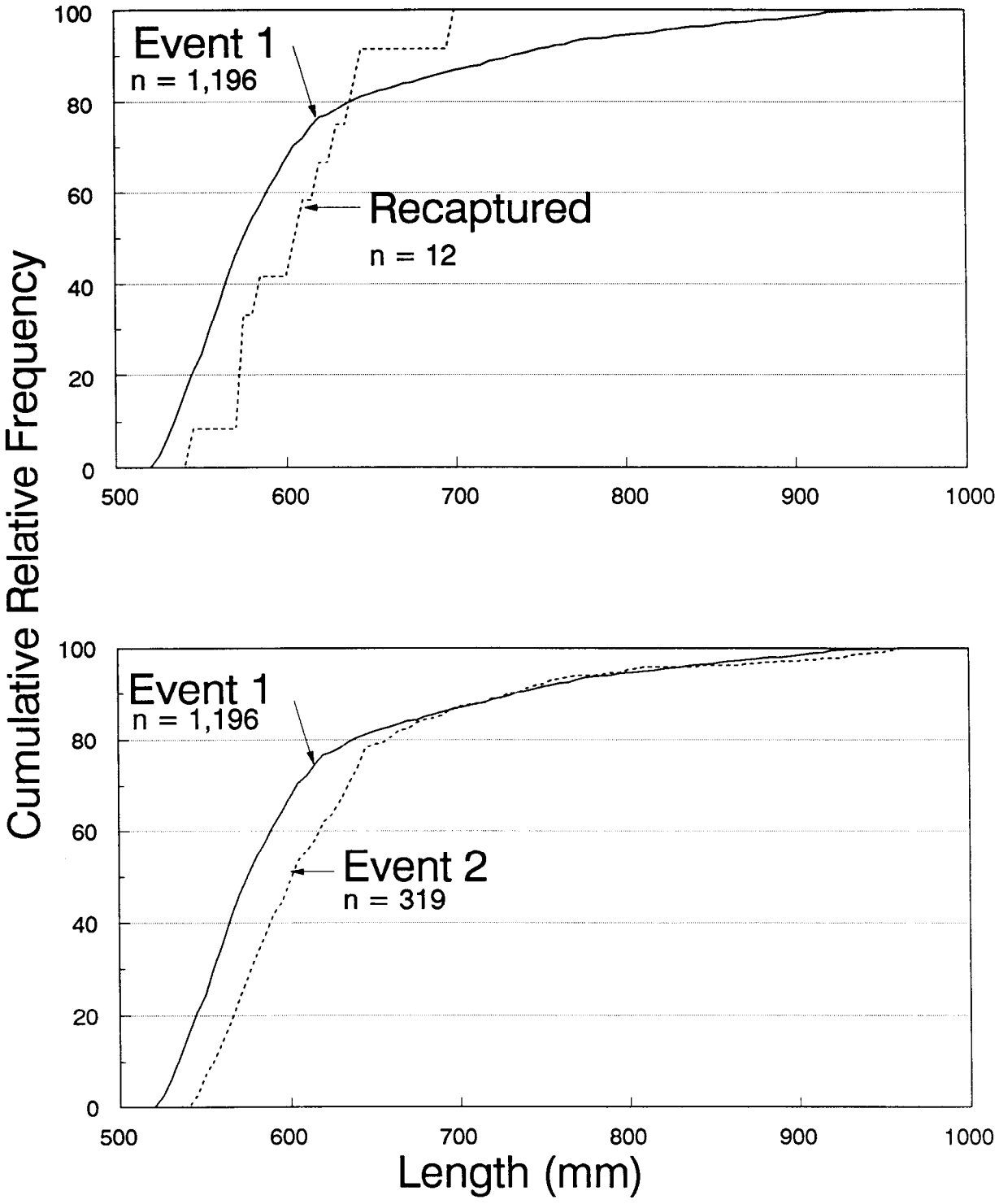

Figure 3. Cumulative length frequency of northern pike captured in Area I of Minto Flats during spring 1990 and spring 1991.

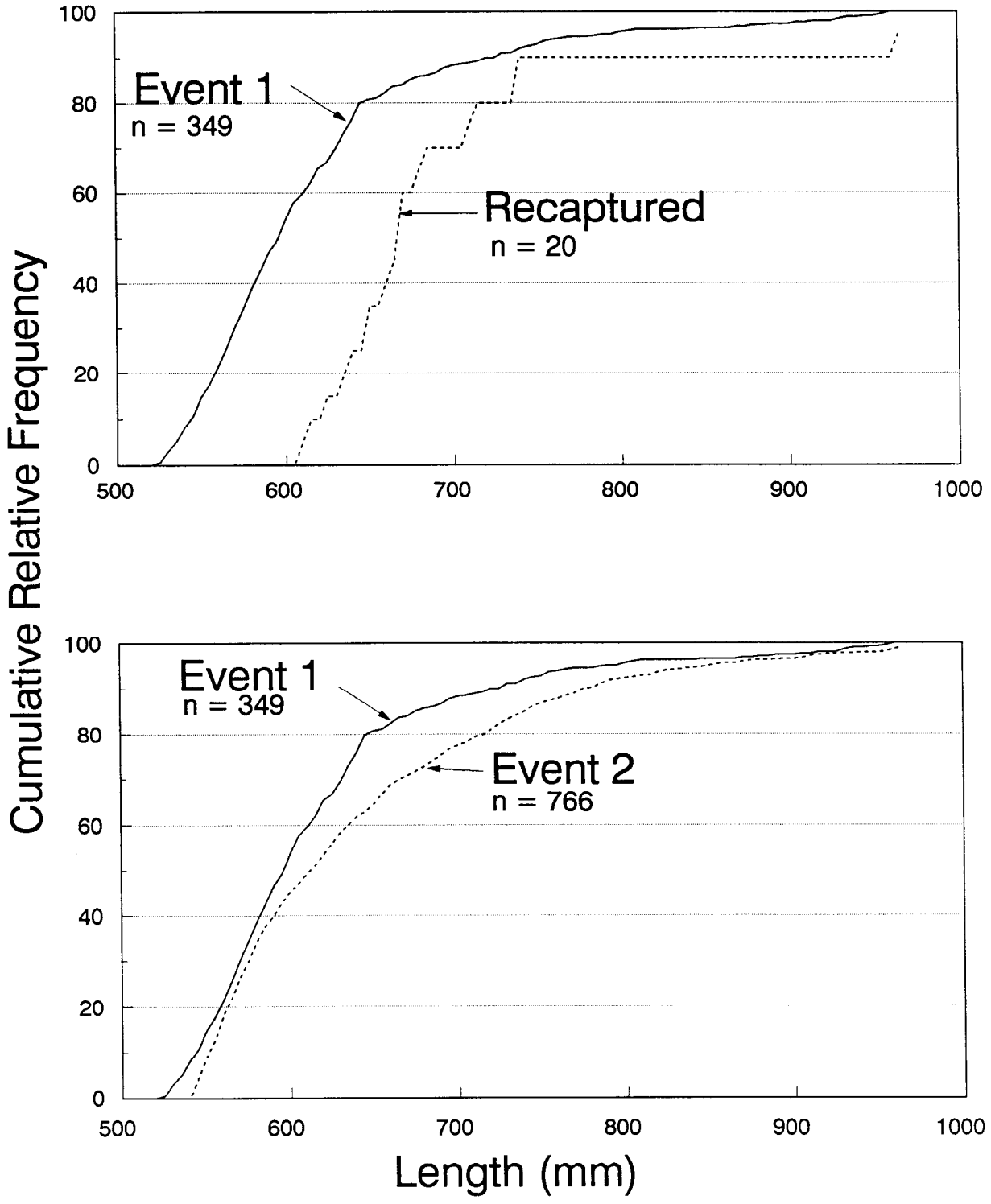

Figure 4. Cumulative length frequency of northern pike captured in Area I of Minto Flats during spring and fall, 1991.

1991. During the fall sampling there was no significant difference in the fraction of the sample with marks among six sublocations within Area I (χ^2 = 6.7, df = 5, P = 0.24) making the assumption that marked fish mix completely with unmarked fish valid. The length distribution of fully recruited northern pike marked during the first event was significantly different from the length distribution of the fully recruited fish examined during the second sampling event (D = 0.17, P < 0.001, Figure 4). The length distributions of fish marked during the first sampling event and those recaptured during the second event were also significantly different (D = 0.58, P < 0.001, Figure 4). The stratified and unstratified estimates (17,633 and 12,782 respectively) differed by 28%, indicating that there was significant bias in the unstratified estimate due to size-selective sampling. Therefore, to reduce bias in the estimate the unstratified estimate was discarded.

Length, Sex, and Age Composition

Quality-sized northern pike accounted for 80.4% of the sample in the spring of 1990 (Table 3). No trophy and few memorable (2.8%) and preferred (14.9%) sized fish were present. In the spring of 1991, quality sized northern pike accounted for 92.5% of the spring sample (Table 4). No trophy and few memorable (1.1%) and preferred (5.5%) sized fish were present.

In 1990 age 5 and age 6 fish comprised the majority (37% and 32%, respectively) of the fully recruited northern pike sampled during the spring (Table 5). Few fish younger than age 5 were present (4% age 4). After age 5, the representation of fish decreased as age increased. In 1991 age 8 and age 9 fish comprised the majority (33% and 24%, respectively) of the fully recruited northern pike sampled (Table 6). Age 5 and age 6 fish made up only 1% and 11% of the sample, respectively. After age 8, the representation of fish decreased as age increased.

During the spring of 1990 sex was determined for 991 males and 524 females. In the spring of 1991 sex was determined for 117 males and 481 females.

Length-at-Age

Ages of all northern pike caught during the spring of 1990 ranged from 2 to 13 and from 3 to 15 in the spring of 1991. The mean lengths-at-age between 1990 and 1991 differed greatly (Figure 5). For all estimated ages, the average length was considerably less in 1991 than in 1990.

DISCUSSION

Previously reported abundance estimates for northern pike in Minto Flats were for Areas I-III and for fish ≥300 mm (Burkholder 1988). These estimates were recalculated in the same manner as the 1990 and 1991 estimates: limiting the estimate to Area I only; restricting the estimate to fish ≥522 mm; and, stratifying the estimate into two length categories. The estimated abundance of northern pike ≥522 mm for Area I of Minto Flats was 11,257 (SE = 3,075) in 1987 and 13,233 (SE = 3,143) in 1988. No estimates were available for 1989 (Figure 6). Estimated abundance of northern pike in 1990 was significantly

Table 3. Percentage of fully recruited northern pike in Relative Stock Density categories in Area I of Minto Flats, spring 1990.

Category	Gabelhouse Minimum Length	Relative Stock Density[a]	SE	Weighted Sample Size
Stock	300 mm	1.9	0.4	23
Quality	525 mm	80.4	6.3	959
Preferred	655 mm	14.9	4.9	179
Memorable	860 mm	2.8	1.0	34
Trophy	1,080 mm	0.0	--	0
Total		100.0		

[a] Relative Stock Density expressed as a percentage: categories taken from Gabelhouse (1984).

Table 4. Percentage of fully recruited northern pike in Relative Stock Density categories in Area I of Minto Flats, spring 1991.

Category	Gabelhouse Minimum Length	Relative Stock Density[a]	SE	Weighted Sample Size
Stock	300 mm	0.9	0.7	2
Quality	525 mm	92.5	2.5	280
Preferred	655 mm	5.5	1.2	54
Memorable	860 mm	1.1	0.4	11
Trophy	1,080 mm	0.0	--	0
Total		100.0		

[a] Relative Stock Density expressed as a percentage: categories taken from Gabelhouse (1984).

Table 5. Age composition of fully recruited northern pike sampled from Area I of Minto Flats during spring 1990.

Age Class	Weighted Sample Size	Sample Proportion	SE
4	44	0.04	0.010
5	369	0.37	0.062
6	320	0.32	0.018
7	107	0.11	0.022
8	55	0.05	0.021
9	39	0.04	0.014
10	41	0.04	0.014
11	17	0.02	0.007
12	6	0.01	0.003
13	1	<0.01	0.001
Total	685	1.00	

Table 6. Age composition of fully recruited northern pike sampled from Area I of Minto Flats during spring 1991.

Age Class	Weighted Sample Size	Sample Proportion	SE
4	1	<0.01	0.001
5	1	0.01	0.006
6	21	0.11	0.024
7	37	0.17	0.028
8	83	0.33	0.034
9	70	0.24	0.030
10	38	0.10	0.021
11	12	0.02	0.008
12	12	0.02	0.008
13	1	<0.01	0.001
15	1	<0.01	0.001
Total	685	1.00	

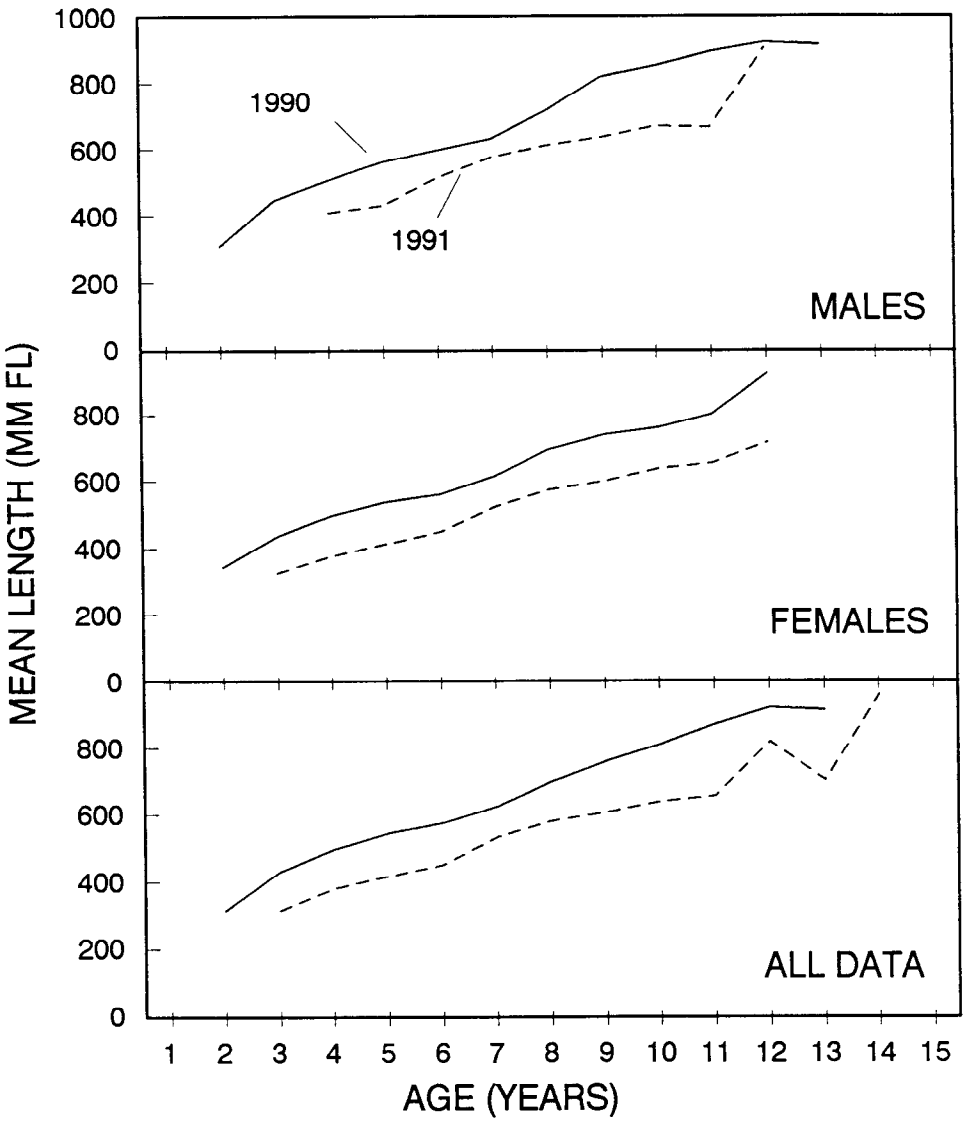

Figure 5. Cumulative length frequency of male and female northern pike captured in Area I of Minto Flats during spring 1991.

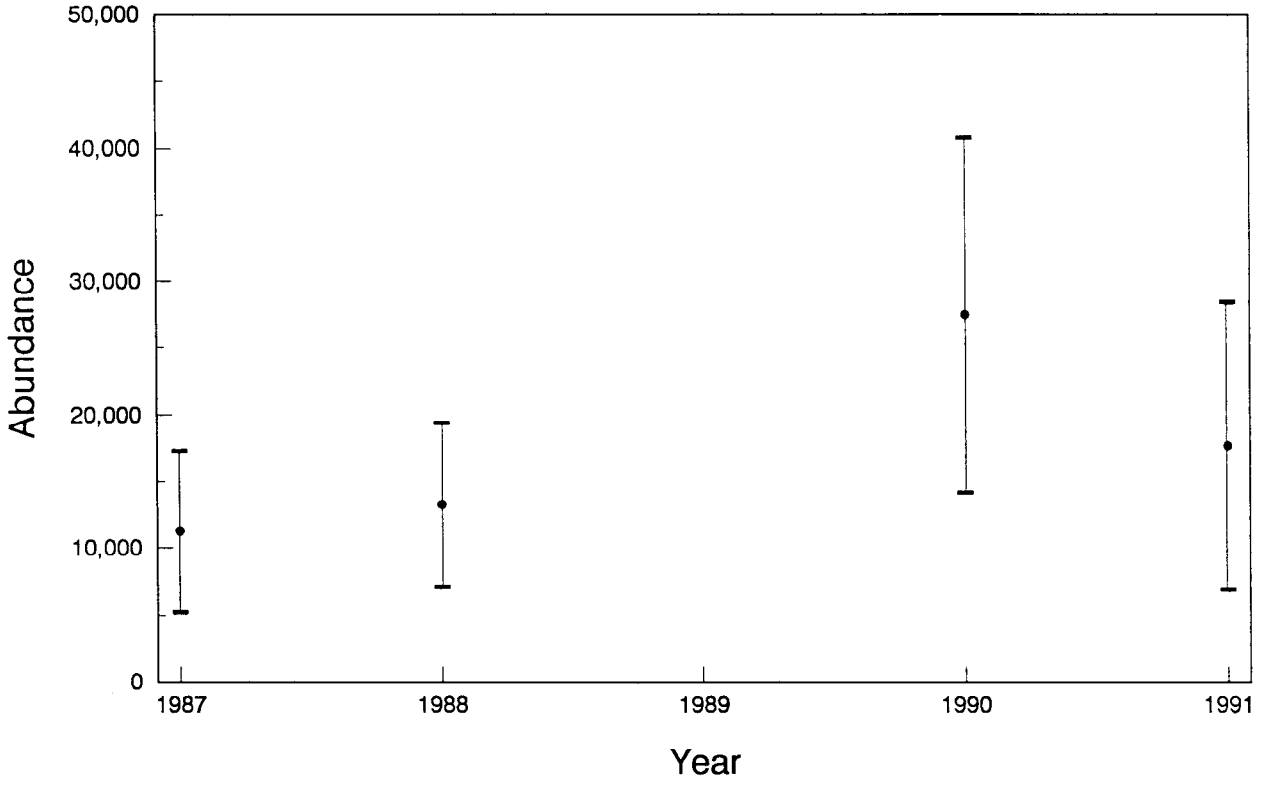

Figure 6. Abundance estimates and 95% Confidence Intervals for fully recruited northern pike in Area I of Minto Flats from 1987-1991.

greater than the estimated abundance in 1987 and 1988 ($Z_{87,90}$ = 2.17, $Z_{88,90}$ = 1.89). The estimate of abundance in 1991 was not significantly different from any previous estimates.

Tag loss could not be calculated for either the 1990 or 1991 population estimates. Tag loss of up to 6% has been reported for northern pike mark-recapture experiments in George Lake (Clark et al. 1988) where the procedures were the same as those used in Minto Flats. Tag loss was also not accounted for in the population estimates in 1987 and 1988.

Ages of northern pike from Minto Flats have been difficult to determine from scales (Pearse and Hansen 1992). The age composition of northern pike in Minto Flats in 1990 was similar to that of other Alaskan northern pike populations. The majority of fish were ages 5 and 6 with steadily decreasing representation after age 6. The mean length-at-age of the northern pike sampled in 1990 was also consistent with other Alaskan populations. The ages determined from scales taken in 1991 are inconsistent with other northern pike populations in Alaska (Figure 5). The age structure in 1991 appears to be biased high by several years.

The Relative Stock Densities of northern pike in Minto Flats has changed little over time and is similar to that of George and Volkmar lakes (Pearse 1990). There was a reduction (statistically not significant) in the representation of preferred and memorable sized fish between 1990 and 1991. The estimated harvest of northern pike from Minto Flats decreased substantially between 1986 and 1987 after the implementation of the current regulations and has remained almost constant since 1987. While the harvest has remained unchanged, the estimated abundance for fully recruited northern pike has increased in recent years. In 1991, 5,427 northern pike were caught of which 2,155 or 40% were harvested. Small fish made up 88% of the catch and 81% of the harvest (Mills 1992). The current regulations have been effective in reducing the sport harvest and the northern pike population appears to be increasing.

ACKNOWLEDGEMENTS

The authors thank Gary Pearse, Bill Arvey, Fred DeCicco, Matt Evenson, Roy Perry, Alan Amundson, Jerry Hallberg, and Nick Hughes for assistance in the field. The efforts of Dave Davenport and Alan Amundson in mounting scales and cleaning other structures for age determination purposes are greatly appreciated. Thanks also to Sara Case for her help in the preparation of the manuscript. The authors are grateful to John Clark, Margaret Merritt, and Dave Bernard for help with various aspects of planning and reviewing of this report.

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